Available online at www.sciencedirect.com

ScienceDirect

Procedia Technology 19 (2015) 387 – 394

Procedia Technology

8th International Conference Interdisciplinarity in Engineering, INTER-ENG 2014, 9-10 October 2014, Tirgu Mures, Romania

Modern aspects of mining in correlation function of risk and environmental sustainability

Slobodan Radosavljević[a], Predrag Dašić[b], Milan Radosavljević[c], Jovana Radosavljević[c]*

[a] *RB "Kolubara" d.o.o., Svetog Save 1., 11550 Lazarevac, Serbia*
[b] *SaTCIP Publisher Ltd., Vrnjačka Banja 36210, Serbia*
[c] GO Lazarevac, Lazarevac, Serbia

Abstract

The time we live in is becoming quite demanding when it comes to the need for energy resources and final friendly energy products. Despite a highly constructive multidisciplinary scientific research effort, electricity has almost no alternative. On one hand, the need for the same in the international relations are growing and other resource potentials every day is actually decreasing. There remains the problem of how to reconcile these trends in the correlation function of the potential risks and environmental sustainability. Thus, the question remains which fewer resources are to provide more final energy for the future development of more rapid global technological processes. Decomposing questions we come to conclusions on the need of unconditional fast and high-quality redesign of existing designs or new technological processes in mining and energy. Modern technologically and qualitatively stable technological processes could provide an answer to the specific conditions in the connotation of the risks that are inevitably to be generated and the position of the overall aspects of compliance with environmental quality. This paper attempts to answer several questions that arise from the subject issues with respect to the real parameters of the demand for energy, accelerated resource exhaustion of world's resource potential and environmental sustainability in the context of the examples of techno-eco practicum in Serbia.

Peer-review under responsibility of "Petru Maior" University of Tirgu Mures, Faculty of Engineering

Keywords: coal; quality; risk; energy; homogenization.

* Corresponding author. Tel.: +381-60-6926690.
E-mail address: dasicp58@gmail.com

Peer-review under responsibility of "Petru Maior" University of Tirgu Mures, Faculty of Engineering
doi:10.1016/j.protcy.2015.02.055

1. Introduction

A very important requirement often forgotten is that the quality of the material to be processed must be stable (with a minimum allowable variations).Oscillation of coal quality can lead to increased costs of production and processing, reduced quality, a temporary interruption of the process production. Solutions that apply today are predictive in character and relatively simple: coal of different quality characteristics (different heat values) were first introduced in the process of mixing (homogenization), and then dispatched to the power plant as input to further technological process of producing electricity. Over time, they developed and are still promoting a very successful technique of homogenization of coal [1-3]. However, the problem of fluctuations in coal quality attracts considerable attention of scientific experts from a number of reasons. Among others, because it causes significant costs in the context of the expenditure of the volume (of materials, optimization of the production of electricity and the necessary time for implementation) and a lot of hard compliance with the requirements of environmental sustainability, given the large number of generated procedural risks are actually more difficult to overcome and comply with the requirements of modern process of global trends [4-7]. Figure 1 represents the spatial position of a colliery surface mining in the mining industry of the Republic of Serbia. Presented in Figure 2 is a block diagram of roofing and present floor coal-bearing series of deposits in an active coal mine, Republic of Serbia. Thus, in order to maintain coal production in existing relationships or to increase it, those involved in the mining industry have to think in the following directions:

- Creation of new alphabetic surface mines (less geological resource reserves of coal);
- Creating new resource stable surface mines for long-term exploitation (large geological resource reserves of coal);
- Improving the technology of surface exploitation through redesign of existing procurement and design of new technical systems and equipment needs;
- The introduction of a quality management system of coal-homogenization;
- Implementation of complex actions to increase energy efficiency in the existing boilers in thermal power plants and systems;
- Reconciliation of process units with the basic definitions of environmental sustainability in the area of macro-and micro-site mining and processing of coal.

2. Quantification of impact homogenization of coal to the environment - analysis

Quality control system for coal using the homogenization process consists of:

- Automatic control system (hardware and software);
- Crushers conveyor belts;
- Feeder (Tray), 4200 tons/hour;
- Portal bucket dredge (Taker), 3500 tons/hour;
- System power supply.
- The main objective is that the quality of the coal in the process of homogenization reaches a value greater than 7.500 kJ/kg, and that the fluctuations in the calorific power of the same quality are below the pre-set value.

Baselines for certain calculations and quantification of impacts (economic, environmental, social) on power plant are:

- Initialization power of 3.300 MW;
- The net power of 3.003 MW;
- The annual production of 19.500 GWh/year;
- Coal consumption of 29.500.000 tons/year;
- Hours of work in the year 6.500 h, hours of work with lower quality coal 975 h;
- Cem electricity € 0.036/kWh;
- Price of fuel oil 350 €/ton.

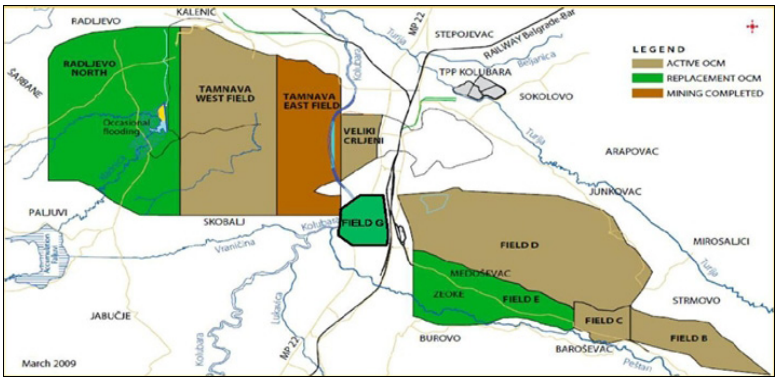

Fig. 1. The spatial position of a colliery surface mining in R. Serbia

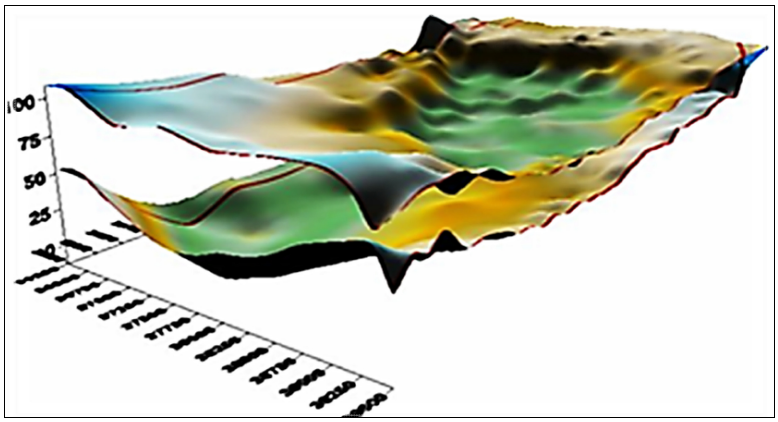

Fig. 2. Block diagram of roof and coal-bearing series present floor deposits in coal

System for coal homogenization reduces emissions of nitrogen oxides, increases economic efficiency of boiler plants, increases techno economic and financial effects of the energy up to 50%. Basics of qualitative contribution of the mining and energy sector and the reduction of gaseous and particulate matter into the air are: 1 kg of coal frees 4.1 Nm^3 of dry fuel gas (an oxygen content up to 6%), and from 1 t/h of coal is obtained 714 kWh of electricity. The composition of the flue gas is CO_2 (O_2 6%) = 1.27 g/Nm^3, NO2 (O_2 6%) = 0.4 g/Nm^3, CO_2 = 1.2 kg CO_2/kWh. Figure 3 shows the interdependence of relationships and connections with change in quality of coal and destructive effects on the operation of boilers of thermal power plants showing potential exposure risk in the context of negative synergies, electrical energy unit of the Republic of Serbia, [8-13].

More complex analyzes show that the system homogenization in mining, the total reduction in energy of smoke gas blocks go up:

- SO_2 = 3.684 t/year;
- NO_2 = 21.370 t/year;
- CO_2 = 555.350 t/year;
- Reducing total ash up to 3%.

Significant environmental effects that can not be disregarded are definitely:

- The amount of waste water that is used to transport ash (about 1.000.000 l/year);
- Extending the life of existing ash disposal;
- Expected increase the energy efficiency of existing electrical filter plant;
- Reducing the amount of waste water that can be caused by construction of desulphurization (lime method, a system with low dramatic temperature plasma or long) in the near future.

The total reduction of emissions and ambient air in the mining sector on the basis of the work of mining machinery and technical systems is:

- Reduction of CO_2 emissions by 1.532.06 kg/year of NOx to 3.781.0 kg/year of VOCs 231.46 kg/year;
- Total reduction of CO_2 in the atmosphere for 3,293 tons/year;
- The elimination of dust immission with work surfaces E = 160 m/second;
- Better use of ore deposits, (savings of natural resources);
- Minimization of fire and fire gases emission from self-combustion of coal in landfills.

Fig. 3. Modern systems for coal homogenization, a landfill site in the open pit

Parameter	Deviation	Influence	Risk
Thermal power	High	Overheating and damage to the burner and boiler heating surfaces	High
		Intensive formation of deposits on all heating surfaces	High
	String	Increase in coal consumption	Medium-High
		Increased transportation costs	Medium-High
		Reducing the production of steam, power and total production block	High-Medium
		The need for support is optional auxiliary fuel flames	Medium-High
		Compromised the safety of the general reliability of the block, a high risk of potential destruction to downtime	High
Mineral content	High	Increased participation of smaller fractions	Medium-High
		Intensive wear of the boiler, transport systems, mills, canals, burners, heating surfaces	Medium-High
		Intensive slogging and fouling of heating surfaces of the boiler	High-Medium
		Increased emissions of particulate matter in the atmosphere	High
		Increased consumption of auxiliary fuel	Medium-High
		Overloading the system, possible delays to downtime	High-Medium
Moisture content	High	Larger fluctuations in the system work	High
		The deterioration of the general condition of the system	High
		The deterioration of general conditions of ignition and combustion of coal	High
Volatile content in coal	Low (<10%)	Shortness of ignition and combustion	Medium-High
The sulfur content	An increased	Increased risk of corrosion	Medium-High
		Reduced electrical resistivity ash, increasing the efficiency of the electrostatic	Low-Medium
	Reduced	The increased electrical resistance of ash, reducing the efficiency of the electrostatic	Medium-High
Grindability of coal	String	The smaller capacity mill, rough grinding, losses due to coal not burning	High-Medium
The melting temperature of the ash	String	Intensive slogging and fouling of heating surfaces of the boiler	Medium-High
Grit coal	High (d> 150mm)	Reduced capacity of the mill, higher energy consumption for grinding coal	High-Medium

Fig. 4. Change coal characteristics and destructive influence on the performance of boilers of thermal power plants showing potential exposure risk in the context of negative synergies, Electricity blocks R. Serbia, [7, 14-17]

In Fig. 3 view of a modern system for homogenization of coal located on site pit mining is shown.

In Fig. 4 the change of coal characteristics and destructive influence on the performance of boilers of thermal power plants showing potential exposure risk in the context of negative synergies, Electricity blocks R. Serbia is shown.

In Fig. 5 methodological example of modern quality control of coal at the site locations of homogenization-show coal block floors digging and sampling procedure from the block with the analysis of the quality of the sample is shown.

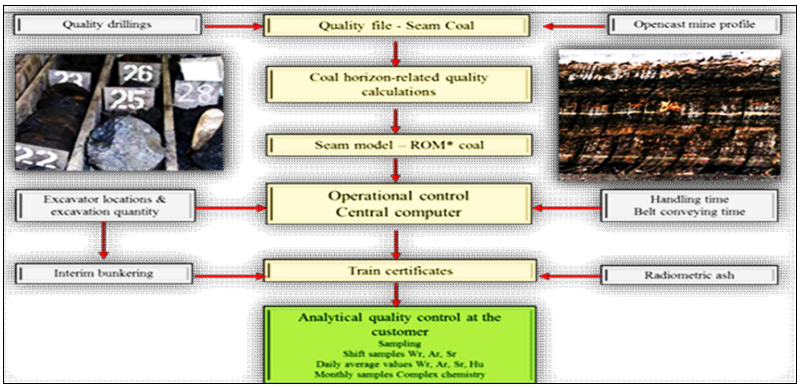

Fig. 5. Methodological example of modern quality control of coal at the site locations of homogenization-show coal block floors digging and sampling procedure from the block with the analysis of the quality of the sample

Quality control system integrated in the operational control centre of the mines includes coal horizon thicknesses and quality values in the 25 m grid for water, ash, sulphur and heating value as well as petrologic quality values for refining coals. That means that the quality is known at the time of excavation. Predefined differentiation of coals for different applications quality values are part of the train certificate. Train certificate is used for homogenization of quality parameters well directed unloading at the power plant bunker [7, 18-20]. Figure 6 presents an overview of some of the basic parameters and the content of various coal blocks in digging.

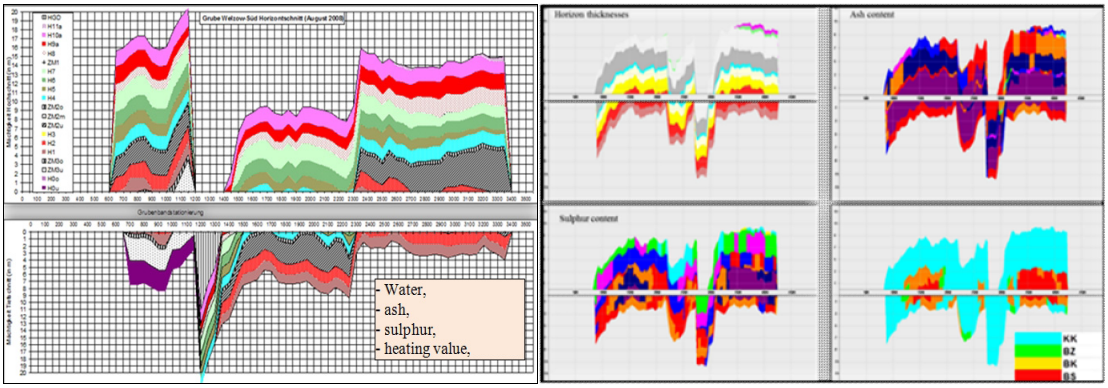

Fig. 6. Showing some of the basic parameters and content of coal block (horizon thicknesses, ash content, sulphur content) and a horizontal section of two coal blocks with two locations open pits comparing with the facilities (water, ash, sulfur and calorific value) of the mix homogenization achieve qualitative improvement of combustion in boilers electric power plants

3. Equipment operating at landfills for coal homogenization

The main purpose is that the landfill is inserted in the technological chain between producers and the processors or in the process of refining and forming a buffer to prevent the interruption of all participants due to short-term (and sometimes longer) supply problems. An additional purpose of the system of homogenization is to serve as a place

where you can perform homogenization or blending coals to ensure consistency of quality of coal to be directed away from the landfill in the process of cleaning, processing or combustion, [7, 21-28]. The size of landfill depends on:

- Capacity of the plant;
- Distances suppliers/customers;
- The reliability of the transmission system;
- Behavior of materials at the landfill;
- Climatic conditions etc.

In Figure 7 shown are the main characteristics of landfills located near power plants in the Republic of Serbia (2014 year). In Figure 8 the display of two types of landfills (circular and linear) volume is shown.

Modern trends in determining the size of the landfill for coal are aimed so that:

- The landfill should be as small as possible, but as great so that production is not threatened;
- Stacking and reclaiming coal from the landfill are treated as an expense;
- Standing coal dump is treated as a temporary freeze capital;
- Depending on the relationship between mines and power plants only one landfill is usually formed, often in mines;
- TE tend to have their landfill, but to supply the mines delivery of coal from mines would block the entrance to the bunker;
- Mines tend to form aggregated and shared landfills, contiguous, thermal power plants;
- Size of individual landfill means a reserve of 3-7 days, a group of up to 30 days (depending on the number of thermal power plants and the conditions of distribution of coal);
- Full exemption from the preceding rules are landfills for coal homogenization;
- The size of the landfill is dependent on establishing the optimal number of layers of coal to homogenize the composition;
- The number of layers depends on the variation of coal quality (such as greater variation to the required number of layers greater).

As a mark of success homogenization can serve ratio of the standard deviation of a parameter of quality of the output from the landfill and the standard deviation of the same parameter at the entrance to the landfill, [29-33].

The values of the indicators of effectiveness of homogenization are in the range 0 (homogenization is ideal) to 1 (no homogenization) and then the system is not functioning.

Thermal Power Plant	Size of the landfill in tons	Coal reserves per day	Type of landfill	The existence mining landfill	
TENT A	850.000	11	Polar	That	Design
TENT B	550.000	12	Polar	That	Design
TE Kolubara	110.000	13	Line	No	
TE Morava	240.000	40	Line	No	
TE Kostolac A	120.000	10	Line	No	Design
Te Kostolac B	600.000	5	Line	No	Design

Fig. 7. Main characteristics of landfills located near power plants in the Republic of Serbia (2014) m

Fig. 8. Two types of (circular and linear) volume

4. Discussion and analysis of orientation of selection

Based on previously presented data, it is necessary with some degree of caution to access choice of the type and model system for homogenization of coal that will give satisfactory performance during its exploitation in the mining and energy sector. In addition to the technical requirements which are very rigorous also needed to be achieved is a certain set of environmental requirements related to the sustainability of the site area of the landfill and the environment at full eco format. Mining in the Republic of Serbia is currently in such a position that in certain locations systems for coal homogenization are agreed upon and they are currently at the stage of basic engineering of the bidder or the implementers of the project solutions. In Figure 9 the preparation and presentation of risk maps for part of the homogenization of coal mining and energy in R. Serbia are shown [7, 34-35.

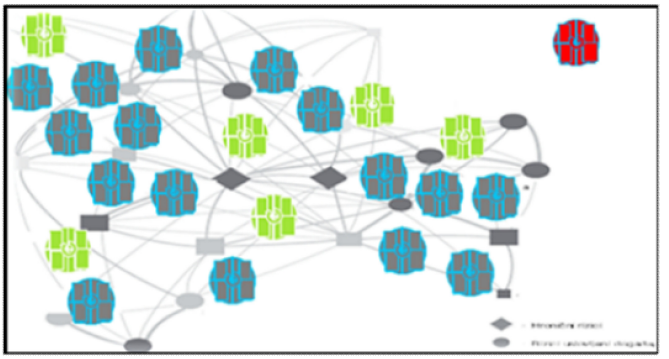

Fig. 9. Preparation and presentation of risk maps for part of the homogenization of coal mining and energy R. Serbia

5. Conclusion

The paper discusses the relationship and connections generated on the line: the choice of an adequate system for homogenization of coal mining and energy as well as destructive potentials in the context of environmental sustainability with the potential risk of exposure to multiple aspect in the context of immediate and distant environment. Possible potential risks at this time are partially positioned but though by now very well known, certain are real, with the possibility of mapping the time, location and cause.

It is extremely difficult on the basis of the above facts and details to explicitly position acceptable threshold potential risks especially in terms of their synergistic complication which are certainly real and possible in the production practice of mining and energy when such systems for coal homogenization are concerned.

These problems worthy of attention and involvement of the scientific and professional community in the context of constant analysis and comprehensive eco-monitoring of global localities and their impact, especially in the context of perspectives and opportunities in the near future for the Republic of Serbia, which should certainly be used.

References

[1] Ben-Daya, M., Duffuaa, S.O., Raouf, A., Knežević, J., Ait-Kadi, D. (editors). Handbook of maintenance management and engineering. London (United Kingdom): Springer-Verlag London Ltd., (2009): 741.

[2] Burhanuddin, M.A., Halawani, S.M., Ahmad, A.R. Chapter 11: An efficient failure-based maintenance decision support system for smalland medium industries. In: Efficient Decision Support Systems – Practice and Challenges from Current to Future. Edited by Chiang Jao. Rijeka (Croatia): InTech Europe, (2011): 195-210.

[3] Cibulka, J., Ebbesen, M.K., Hovland, G., Robbersmyr, K.G., Hansen, M.R. A review on approaches for condition based maintenance in applications with induction machines located offshore. Modeling, Identification and Control, 33 (2), (2012): 69-86.

[4] Guide to meteorological instruments and methods of observation. Technical Report WMO-No. 8. Geneva (Switzerland): World Meteorological Organization (WMO), (2008): 680.

[5] Guide to the approximation of European Union environmental legislation. Brussels (Belgium): European Commission, (2012): 140.

[6] Internal documentation of the Kolubara Mining Basin doo. Lazarevac (Serbia): Kolubara Mining Basin doo, (2014).
[7] ISO 31000:2009 Risk management -- Principles and guidelines. Geneve (Switzerland): International Organization for Standardizations (ISO), (2009): 24.
[8] Junca, M., Sanchez-Silva, M. Optimal maintenance policy for permanently monitored infrastructure subjected to extreme events. Probabilistic Engineering Mechanics, 33, (2013): 1-8.
[9] Kans, M. The advancement of maintenance information technology: A literature review. Journal of Quality in Maintenance Engineering, 15 (1), (2009): 5-16.
[10] Klimont, Z., Smith, S.J., Cofala, J. The last decade of global anthropogenic sulfur dioxide: 2000–2011 emissions. Environmental Research Letters, 8 (1), (2013): Article no. 014003: 1-6.
[11] Liyanage, J.P., Lee, J., Emmanouilidis, C., Ni, J. Chapter 20: Integrated e-maintenance and intelligent maintenance systems. In: Handbook of maintenance management and engineering. Edited by Mohamed Ben-Daya, Salih O. Duffuaa, Abdul Raouf, Jezdimir Knežević and Daoud Ait-Kadi. London (United Kingdom): Springer-Verlag London Ltd., (2009): 499-546.
[12] Macchi, M., Garetti, M. Information requirements for e-maintenance strategic planning: A benchmark study in complex production systems. Computers in Industry, 57 (6), (2006): 581–594.
[13] Main, W. B., Cloutier, R.D., Manuele, A.F., Bloswick, S.D. Risk assessment for maintenance work. Working Paper. Arbor (Michigan – USA): Design Safety Engineering Inc., (2005).
[14] Muller, A., Marquez, A.C., Iung, B. On the concept of e-maintenance: Review and current research. Reliability Engineering & System Safety, 93 (8), (2008): 1165-1187.
[15] National Strategy of Serbia for the approximation of the environment. Belgrade: Ministry of Environment, Mining and Spatial Planning, (2011): 95.
[16] Pintelon, L. M., Parodi-Herz, A. Chapter 2: Maintenance: An evolutionary perspective. In: Complex System Maintenance Handbook: Springer Series in Reliability Engineering. Edited by Khairy A.H. Kobbacy and D.N. Prabhakar Murthy. London (United Kingdom): Springer-Verlag London Ltd., (2008): 21-48.
[17] Radosavljević, S., Dašić, P., Radosavljević, M. Appendix specifics of risk management in mining. Metalurgia International, 18, Special Issue (8), (2013): 59-68.
[18] Radosavljević, S., Dašić, P., Radosavljević, M. Individual maintenance engineering in energy and mining-based of risk. Metalurgia International, 18 (6), (2013): 79-86.
[19] Radosavljević, S., Lilić, N., Ćurčić, S., Radosavljević, M. Risk assessment and managing technical systems in case of mining industry. Strojniški vestnik – Journal of Mechanical Engineering, 55 (2), (2009): 119-130.
[20] Radosavljević, S., Radosavljević, M. Risk assessment in mining industry – Apply management. Serbian Journal of Management, 4 (1), (2009): 91-104.
[21] Saharkhiz, E., Bagherpour, M., Feylizadeh, M. R., Afsari, A. Software performance evaluation of a computerized maintenance management system: A statistical-based comparison. Eksploatacja i Niezawodność – Maintenance and Reliability, 14 (1), (2012): 77-83.
[22] Shafie, M., Chukova, S. Maintenance models in warranty: A literature review. European Journal of Operational Research, 229 (3), (2013): 561-572.
[23] Shimizu, S., Sugawara, M., Sakurai, S., Mori, T., Saikawa, K. Decision-making support systems for reliability-centered maintenance. Journal of Nuclear Science and Technology, 30 (6), (1993): 505-515.
[24] Smith, A. M. Reliability centered maintenance. New York (New York – USA): McGraw-Hill Inc., (1993): 216.
[25] Smith, A. M., Hinchcliffe, G. R. RCM – Gateway to world class maintenance. Oxford (England): Elsevier Butterworth–Heinemann, (2004): 337.
[26] Todić, D., Ignjatić, M., Katic, M., Plavsic, P. (eds.): The competence and capacity of local governments and civil society organizations for the implementation of European standards in the field of environment. Belgrade: European Movement in Serbia, (2012): 575.
[27] Tsang, A.H.C. Conidition-based maintenance: Tools and decision making. Journal of Quality in Maintenance Engineering, 1 (3), (1995): 3-17.
[28] Tsang, A.H.C. Strategic dimensions of maintenance management. Journal of Quality in Maintenance Engineering, 8 (1), (2002): 7-39.
[29] World Energy Outlook 2013. Paris (France): International Energy Agency (IEA), (2013): 708.
[30] Yu, R., Lung, B., Panetto, H. A multi-agent based E-maintenance system with case-based reasoning decision support. Engineering Applications of Artificial Intelligence, 16 (4), (2003): 321-333.
[31] Zhang, Y.-L., He, Y.-Z. Avionic maintenance information management system. Avionics Technology, 38 (2), (2007): 41-45.
[32] Zhang, W. Knowledge management for e-maintenance of industrial automation systems. In: Studies in Computational Intelligence, Vol. 42: Contributions to Ubiquitous Computing. Edited by Bernd J. Krämerand and Wolfgang A. Halang. Berlin-Heidelberg (Germany): Springer-Verlag GmbH, (2007): 139-155.
[33] http://corporate.vattenfall.com/.
[34] Vels, B. Envorinmental and Techno-economic Assesment of PEU Resavica, (2008).
[35] Engineering and Design Manual, Coal Refuse Disposal Facilities, Second Edition, US Department of Labor, (2009).